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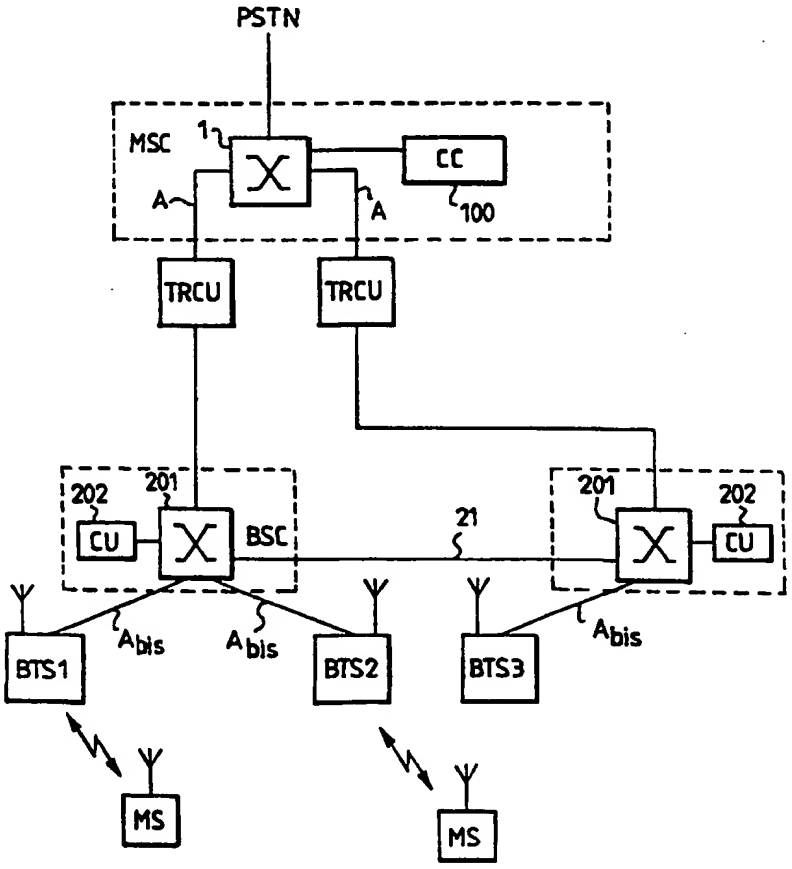
(54) Title: MOBILE COMMUNICATION SYSTEM AND CALL CONTROL METHOD

(57) Abstract

The invention relates to a mobile communication system comprising transcoder units (TRCU) located remote from base stations (BTS1, BTS2) for decoding an encoded speech signal received from a mobile station (MS) and for encoding a speech signal to be transmitted to a mobile station. For switching the calls, there are network connections that are allocated call-specifically between a base station, a base station controller and a mobile services switching centre, a speech signal being transmitted over said network connections in transmission frames. In accordance with the invention, the base station controller switches a local speech or data connection under control of the mobile services switching centre, without a need to establish a speech/data connection between the base station controller and the mobile services switching centre when two mobile stations are located in the area of the same base station system. If there is a direct transmission link (21) between two base station controllers, they will switch network connections directly between the base stations located within their area. The invention also relates to call control methods.



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Mobile communication system and call control method

Field of the Invention

The invention relates to a mobile communication system comprising at least mobile stations; base station systems, each comprising a base station controller and several base stations; mobile services switching centres, each comprising call control means and switch means for controlling and switching calls of mobile stations; and transcoder units, each comprising encoding and decoding means for decoding an encoded speech signal received from a mobile station, and for encoding a speech signal to be transmitted to a mobile station. For switching the calls, there are network connections that are allocated call-specifically between a base station, a base station controller and a mobile services switching centre, a speech signal being transmitted in transmission frames over said network connections, the base stations and the transcoder units comprising means for building, debuilding and synchronizing the transmission frames, the uplink transmission frames transmitted by the base station to the transcoder unit containing synchronizing information on the basis of which the transcoder unit times the transmission of the downlink transmission frames to the base station.

Background of the Invention

In cellular or trunked radio systems, generally referred to as mobile communication systems, a mobile radio station, i.e. a mobile station communicates with a fixed network via a fixed radio station, i.e. a base station that is located in a cell. Mobile stations may freely move from one cell to another in the area of the system. A general principle of the mobile communication

networks is always to direct telephone communication to the area in which a mobile station is currently located. In order to be able to route the incoming calls to the mobile station, the radio network maintains location registers, in which the location of the mobile station is known with an accuracy of one or more base stations. A mobile services switching centre or a base station controller control switching of a call to the correct base station. A base station controller is used when the base stations are grouped into base station systems comprising several base stations having a common base station controller. A mobile services switching centre controls telephone communication within its service area and connects the base station controllers to the outside world.

GSM (Global System for Mobile Communication) is a pan-European telecommunication system, which is becoming a world-wide standard. Figure 1 presents very briefly a few basic components of the GSM system, not paying closer attention to their characteristics or other aspects of the system. A mobile services switching centre (MSC) is in charge of switching incoming and outgoing calls. It performs similar operations as the exchange of a public switched telephone network. In addition, it also performs operations typical of mobile telecommunication only, such as subscriber location management. Mobile radio stations, i.e. mobile stations are switched to the centre MSC by means of base station systems. A base station system comprises a base station controller BSC and base stations BTS. A base station controller BSC is used for controlling several base stations.

The GSM system is completely digital, and speech and data transmission also take place completely digitally, which enables a uniform high quality of

speech. From the point of view of the network, the most limited resource is the radio frequency link needed on the radio path between the mobile stations and the base stations. In order to reduce the radio frequency band needed by the radio connection, speech coding is employed in the speech transmission, which speech coding is more efficient than the 64 bit/s transmission typically employed in telephone networks. A mobile station must naturally comprise a speech encoder and decoder for speech coding. In the network, various speech encoding and rate adapting operations are concentrated in a transcoder unit TRCU (Transcoder/Rate Adaptor Unit). The TRCU may be located in several alternative locations within the system, according to the choices made by the manufacturer. When the transcoder unit TRCU is located remote from the base station BTS, information is transmitted between the base station BTS and the transcoder unit TRCU in so called TRAU frames. Four types of frames are defined, depending on the type of information included in them. These are speech frame, operation and maintenance frame, data frame, and a so called idle- speech frame.

A transcoder unit is typically located at the mobile services switching centre MSC, but it may also be a part of the base station controller BSC or the base station BTS. A transcoder unit located remote from the base station BTS must know some radio parameters for effective decoding. In addition, the timing of the transcoder unit must be adapted for the transmission of the frames over the radio path so that the frames arrive from the transcoder unit at the base station synchronized with the transmission over the radio path (this minimizes the delay owing to a remotely located transcoder unit). Specific in band -signalling is employed for this control and synchronization of the

transcoder unit on a 16 bit/s channel between the base station and the transcoder unit, which channel is used for the transmission of speech or data. The remote control of the transcoder unit is defined in recommendation GSM 08.60. In order to carry out synchronization, the first two octets of each frame contain 16 synchronizing bits. In addition, the first bit of the 16-bit words the frame is composed of (2 octets) is a check bit for synchronizing. All frames contain, in addition to bits including actual speech, data or operation/maintenance information, control bits for transmitting information on the type of the frame and a varying amount of other frame-type specific information. In addition, e.g. in speech and idle frames the last four bits are allocated for the above mentioned timing adjustment.

The interfaces of a transcoder unit are a 64 kbit/s PCM (Pulse Code Modulation) interface (A Interface) towards the mobile services switching centre (MSC) and a 16 kbit/s GSM interface towards the base station BTS. In the context of these interfaces, terms uplink and downlink -direction are used in the GSM recommendations, of which terms the uplink -direction refers to the direction from the base station BTS and to the mobile services switching centre MSC, whereas the downlink direction is the opposite direction to the uplink direction.

When a call is established from a mobile station MS to a public switched telephone network (PSTN) in a system in accordance with the recommendations, the call-related signalling is transferred from the base station BTS to the mobile services switching centre MSC, which, in turn, establishes connections between the connecting line to the public switched telephone network PSTN and the channel in the above mentioned A interface.

Simultaneously, the transcoder unit TRCU is allocated and switched to the channel in the A interface. The mobile services switching centre MSC further gives the base station controller BSC a command to connect the base station BTS with which the calling mobile station MS has a radio connection to the above allocated channel of the A interface. The base station controller BSC establishes a connection between the above allocated A interface channel and further the base station BTS with which the calling MS is communicating. The base station BTS is independently in charge of establishing the connections over the radio path. Thus, a connection is achieved in which a mobile station MS, a base station BTS, a base station controller BSC, a transcoder unit TRCU, a mobile services switching centre MSC and a public switched telephone network PSTN are connected in series. In this case, encoded speech is transmitted via this connection between MS-TRCU and TRAU frames between BTS-TRCU.

When a call is going on between two mobile stations MS located within the area of the same base station or the same base station controller, the call is switched as to the calling mobile station MS in the same way as described above, but the mobile services switching centre now establishes a connection between the A interface channel allocated for the calling mobile station MS and the A interface channel of the called mobile station MS. From this second transcoder unit, in turn, a connection is established back to the same base station controller BSC, and further to the base station of the called mobile station MS. In other words, all calls between mobile stations MS subject to e.g. the same base station BTS are routed until the mobile services switching centre, and each call is allocated two transcoder units. Long routing of this kind wastes

the transmission capacity between the base station controller BSC and the mobile services switching centre MSC, as well as the switching capacity of the MSC. Using or renting transmission links may have a crucial effect on the expenses of the network operator. Secondly, a solution of this kind consumes transcoder resources, since two transcoder units are switched along with each MS-MS connection. The number of the transcoder units must be planned in accordance with the traffic peaks, in which case the number of the transcoder units is too high in a normal situation, both as to the costs and the number of the units. Furthermore, successive transcoding and decoding measures between the base station controller BSC and the mobile services switching centre MSC impair the quality of the speech signal and cause delay for the effective signal.

The above mentioned facts have not caused too much inconvenience so far, since relatively few calls have been mobile-to-mobile calls.

In the future, however, cordless telephone exchanges, "radio PABX", will be taken into use subject to mobile communication systems to replace internal telephone exchanges in offices. In private telephone exchanges of this kind, large numbers of calls between extensions, or so called internal calls are made, and thus a large number of calls on the level of the mobile communication system will be switched from MS to MS, as well. Thus, normal call switching of the same type as in GSM, via a mobile services switching centre, will cause inconvenience, since a very large number of calls take place within the area of one single base station controller BSC, or even in the area of the same base station BTS.

Summary of the Invention

The object of the present invention is to save the transmission and transcoder resources of a mobile communication network, as well as to improve the quality of speech by avoiding the above mentioned problems.

This is achieved with a mobile communication system set forth in the introduction, which is characterized in accordance with the invention that a base station controller BSC establishes network connections directly between the base stations located in the area of the same base station system under control of a mobile services switching centre MSC so that the uplink transmission frames transmitted by a base station, and the encoded speech signal included in the uplink transmission frames are forwarded as such to another base station.

The invention further relates to a second mobile communication system of the type set forth in the introduction, characterized in accordance with the invention in that there are direct network connections between at least some of the base station controllers (BSC), and that such base station controllers (BSC) switch network connections directly between the base stations located in the area of two different base station systems under control of a mobile services switching centre (MSC) so that the uplink transmission frames transmitted by a base station are forwarded as such to another base station.

The invention further relates to a call control method for a mobile communication system of the type set forth in the introduction, which method is characterized by

checking, prior to allocating network connections for a call, if the calling and the called mobile station are located in the area of the same base

station system, and if the mobile stations are located in the area of the same base station system

A) commanding the base station controller of said base station system to switch a connection directly between the base stations of said mobile stations under control of the mobile services switching centre (MSC),

B) forwarding the uplink transmission frames transmitted by a base station as such to another base station.

C) commanding the base stations to disregard whether the transmission frame is of uplink or downlink type.

The invention further relates to a second call control method for a mobile communication system of the type set forth in the introduction, which method is characterized by

checking, prior to allocating network connections for a call, if the calling and the called mobile station are located in the area of two base station systems having a direct network connection between them,

if the mobile stations are located in the area of two base station systems having no direct network connection between them, switching a call via a mobile services switching centre,

if the mobile stations are located in the area of two base station systems having a direct network connection between them,

A) commanding said base station controllers of the base station systems to switch a connection directly between each other, and further between the base stations of said mobile stations under control of the mobile services switching centre (MSC),

B) forwarding the uplink transmission frames transmitted by a base station as such to another base station.

C) commanding the base stations to disregard whether the transmission frame is of uplink or downlink type.

In accordance with the invention, the base station controller switches a local speech or data connection under control of the mobile services switching centre without a need to establish a speech/data connection between the base station controller and the mobile services switching centre. The connection is switched by means of an internal switch of the base station controller when two mobile stations are located in the area of the same base station system. In another embodiment of the invention, there is a direct transmission link between two base station controllers, and the base station controllers switch the network connections directly between the base stations located the area of two base station systems under control of the mobile services switching centre so that the uplink transmission frames transmitted by one base station are transmitted as such to another base station.

Since a network connection is switched directly between two base stations, the two transcoder units needed in prior art systems are also omitted from the connection. This reduces the number of the transcoder units needed in the system and, on the other hand, improves the quality of speech on the connection when unnecessary transcoding and decoding measures are omitted. The difference owing to the omission of the transcoder units compared with prior art is that the uplink transmission frame of one base station is a downlink transmission frame of another base station. Therefore, in a preferred embodiment of the invention,

the base station controller commands the base stations to disregard the check of the frame type.

As the transcoder units located on the transmission link between the mobile stations may be avoided with the aid of the system, the total delay of the transmission link also decreases significantly. A part of this error margin that becomes vacant may be allocated by omitting the usual timing adjustment of the transmission frame between the base stations. Although the delay and thus the need for buffering slightly increase owing to this, the implementation of the base station is more simple as the base station does not attempt to adjust the timing of the transmission frames to an optimal state.

Brief Description of the Drawings

In the following, the invention will be explained with the aid of the preferred embodiments, with reference to the attached drawings, in which

Figure 1 shows a known mobile communication system, and

Figure 2 shows a mobile communication system in accordance with the invention.

Preferred Embodiments of the Invention

The present invention may be applied in any cellular or trunked mobile communication system that utilizes digital speech transmission and speech coding techniques lowering the transmission rate, the coding unit connected to which is located remote from the base station, e.g. at the mobile services switching centre and in which the encoded speech signal is transmitted in transmission frames between the transcoder and the base stations. The first embodiment of the invention, not limited thereto, however, is the pan-European digital mobile communication system GSM (Global System for Mobile Communications) and DCS1800 (Digital

Communication System). The basic components of the GSM system are described in the GSM recommendations. The GSM system is described in greater detail in these recommendations and in the book "The GSM System for Mobile Communication", M. Mouly & M. Pautet, Palaiseau, France, 1992, ISBN:2-9507190-0-7, which are incorporated herein by reference.

The GSM system is completely digital, and speech transmission is also carried out completely digitally. The speech encoding method used in speech transmission is RPE-LTP (Regular Pulse Exitation - Long Term Prediction), which utilizes both long-term and short-term prediction. The encoding results in LAR-, RPE- and LTP-parameters, which are transmitted instead of actual speech. Speech transmission is described in the GSM recommendations in chapter 06, speech encoding especially in paragraph 06.10. Since the actual invention does not relate to the speech encoding method itself and is independent of it, will not be discussed further herein.

As mentioned above, different speech encoding and rate adapting operations are concentrated in the network in a transcoder unit TRCU (Transcoder/Rate Adaptor Unit). As also mentioned above, when the transcoder unit TRCU is located remote from the base station BTS, e.g. at the MSC, information is transmitted between the base station BTS and the transcoder unit TRCU in so called TRAU frames. The TRAU frames and their transmission procedures are described in the GSM recommendations 8.60.

As mentioned above, a call between mobile stations MS under control of the same base station BTS or the same base station controller BSC causes a situation as shown in Figure 1, in which a call is routed from the base station system to the mobile

services switching centre, in which two transcoder units TRCU are allocated, subsequent to which the call is routed back the same base station system. This causes the problems described above, such as increase in the number of the transcoder units needed, impairment in the quality of speech, long transmission delays, increase in the number of the transmission channels needed etc.

Figure 2 shows a block diagram of the mobile communication system in accordance with the invention. A transcoder unit TRCU is located between a mobile services switching centre MSC and a base station controller BSC. The A interface of the transcoder unit is connected by means of switch 1 either to a public services telephone network PSTN or to the A interface of another transcoder unit. Thus, switch 1 switches connections through the mobile services switching centre and transmits signalling messages between a call control computer 100 and the base station systems. The operation of switch 1 is controlled by the call control computer 100.

In accordance with the invention, an internal switch of the base station controller BSC is arranged to switch the mobile stations MS located in the area of the same base station system under control of the mobile services switching centre. Thus, establishing transmission connections and a transcoder unit TRCU between a base station controller and a mobile services switching centre may be completely avoided. Figure 2 only shows the functional blocks that are essential for the invention, in addition to which the base station controller may include various other operations, which do not need to be described herein, however. The operation of the base station controller is controlled by a control unit 202, which transmits and receives signalling messages. The control unit 202 controls

switch 201 on the basis of the control messages received from the mobile services switching centre to switch and release connections between the network links established to the base stations when both mobile stations are located in the area of the same base station system.

There may also be a direct network link between two base station controllers BSC which are under control of the same mobile services switching centre MSC, as illustrated in Figure 2 by means of a link 21. Thus, in a situation in which mobile stations MS are under control of two base station controllers BSC communicating with each other via a direct network link, the base station controllers may switch a connection between the mobile stations directly via said direct network link under control of the mobile services switching centre MSC.

In the following, the operation of the mobile communication system of the invention will be described with an example in which mobile stations are located in the area of the same base station controller. A calling mobile station MS (A) initiates the call set-up to a called mobile station MS (B) located in the area of the same base station system. In that situation, a base station BTS1 starts normal signalling via the base station controller BSC to the mobile services switching centre MSC. The mobile services switching centre MSC finds out the location of the called mobile station MS (B) from the subscriber location register stored in the database of the network, and, subsequent to a successful search, finds that the called mobile station is located in the area of the same base station system as the calling mobile station MS (A). Subsequent to this, the mobile services switching centre MSC transmits a control message to the base station controller BSC as a response

to which control message the BSC establishes a network connection between the base station BTS in the area of which the called subscriber MS (B) is located and the base station controller BSC, as well as between the base station controller BSC and the base station BTS in the area of which the calling mobile station MS (A) is located. Subsequent to this, the base station controller BSC switches the so established network connections of two base stations to each other. The management of the call established between mobile stations MS (A) and MS (B) is carried out by the call control computer of the mobile services switching centre MSC in the same way as in conventional radio systems. When the call needs to be released, the mobile services switching centre MSC transmits a message to the base station controller BSC, on the basis of which message the traffic channels allocated from the radio path to the base stations for the connection are released, and the internal switch 201 of the BSC releases the connection.

In the system according to the invention, the TRAU frames transmitted by two base stations and the encoded speech signal included in the frames are transmitted as such from a base station to another in both directions in the internal calls of a base station controller. Thus, two transcoder units TRCU used in conventional systems are omitted from the connection, which units were used in both transmission directions for releasing the TRAU frames incoming from the base stations, decoding the encoded speech signal/ re-encoding the decoded speech signal and re-building the TRAU frames transmitted to another base station. In an internal call established in accordance with the invention, both base stations receive uplink frames transmitted by the other base station. Since a base station normally receives downlink frames, the operation

of the base station is changed in the solution of the invention to accept uplink TRAU frames, as well, or alternatively, to omit the check totally in that respect. Omitting the check of the type of the uplink and downlink transmission frame is the simplest way to enable reception of TRAU frames from another base station. Furthermore, since the delay caused by the mobile services switching centre and the transcoder units TRCU is omitted from the connection, a part of this error margin may be utilized by omitting the timing adjustment of the TRAU frames in accordance with the GSM recommendations from the traffic between the base stations.

The operation of the system of the invention in a case in which a call is established in accordance with the invention between two base station controllers BSC communicating via a direct network link and being under control of the same mobile services switching centre MSC is in principle similar to the above described internal call in the area of one base station controller BSC. The only difference is that the mobile services switching centre MSC now controls two base station controllers BSC to establish and release the connections with the mobile stations connected with them and to switch these connections to each other via a direct network link interconnecting the base station controllers.

The figures and the description referring thereto are only intended to illustrate the present invention. The mobile communication systems and call control methods of the invention may vary in their details within the scope of the attached claims.

Claims:

1. A mobile communication system comprising at least mobile stations (MS); base station systems, each comprising a base station controller (BSC) and several base stations (BTS); mobile services switching centres (MSC), each comprising call control means and switch means for controlling and switching calls of mobile stations; and transcoder units (TRCU), each comprising encoding and decoding means for decoding an encoded speech signal received from a mobile station, and for encoding a speech signal to be transmitted to a mobile station; network connections that are allocated call-specifically between a base station, a base station controller and a mobile services switching centre, a speech signal being transmitted in transmission frames over said network connections, the base stations and the transcoder units comprising means for building, debuilding and synchronizing the transmission frames, the uplink transmission frames transmitted by the base station to the transcoder unit containing synchronizing information on the basis of which the transcoder unit times the transmission of the downlink transmission frames to the base station, c h a r a c t e r i z e d in that a base station controller (BSC) establishes network connections directly between the base stations located in the area of the same base station system under control of a mobile services switching centre (MSC) so that the uplink transmission frames transmitted by a base station, and the encoded speech signal included in the uplink transmission frames are forwarded as such to another base station.

2. A mobile communication system as claimed in claim 1, c h a r a c t e r i z e d in that the call control (100) of the mobile services switching centre checks, prior to allocating network connections for a

call, whether the calling and the called mobile station are located in the area of the same base station system, and if the mobile stations are located in the area of the same base station system, the mobile services switching centre transmits a message to the base station controller, as a result of which an internal switch (201) of the base station controller switches a direct connection between the mobile stations.

3. A mobile communication system comprising at least mobile stations (MS); base station systems, each comprising a base station controller (BSC) and several base stations (BTS); mobile services switching centres (MSC), each comprising call control means and switch means for controlling and switching calls of mobile stations; and transcoder units (TRCU), each comprising encoding and decoding means for decoding an encoded speech signal received from a mobile station, and for encoding a speech signal to be transmitted to a mobile station; network connections that are allocated call-specifically between a base station, a base station controller and a mobile services switching centre, a speech signal being transmitted in transmission frames over said network connections, the base stations and the transcoder units comprising means for building, debuilding and synchronizing the transmission frames, the uplink transmission frames transmitted by the base station to the transcoder unit containing synchronizing information on the basis of which the transcoder unit times the transmission of the downlink transmission frames to the base station, c h a r a c t e r i z e d in that there are direct network connections (21) between at least some of the base station controllers (BSC), and that such base station controllers (BSC) switch network connections directly between the base stations located in the area of two different base

station systems under control of a mobile services switching centre (MSC) so that the uplink transmission frames transmitted by a base station are forwarded as such to another base station

4. A mobile communication system as claimed in claim 3, c h a r a c t e r i z e d in that the call control (100) of the mobile services switching centre checks, prior to allocating network connections for a call, whether the calling and the called subscriber are mobile stations located in the area of two different base station systems having a direct network connection between them,

and if so, the mobile services switching centre transmits messages to both base station controllers with the result that the internal switches (201) of the base station controllers switch a connection between the base station controllers and further between the base stations of said mobile stations.

5. A mobile communication system as claimed in any of the preceding claims, c h a r a c t e r i z e d in that the base stations disregard the check of the type of the uplink or downlink transmission frame.

6. A call control method in a mobile communication system comprising at least mobile stations (MS); base station systems, each comprising a base station controller (BSC) and several base stations (BTS); mobile services switching centres (MSC), each comprising call control means and switch means for controlling and switching calls of mobile stations; and transcoder units (TRCU), each comprising encoding and decoding means for decoding an encoded speech signal received from a mobile station, and for encoding a speech signal to be transmitted to a mobile station; network connections that are allocated call-specifically between a base station, a base station controller and

a mobile services switching centre, a speech signal being transmitted in transmission frames over said network connections, the base stations and the transcoder units comprising means for building, debuilding and synchronizing the transmission frames, the uplink transmission frames transmitted by the base station to the transcoder unit containing synchronizing information on the basis of which the transcoder unit times the transmission of the downlink transmission frames to the base station, c h a r a c t e r i z e d by

checking, prior to allocating network connections for a call, if the calling and the called mobile station are located in the area of the same base station system, and if the mobile stations are located in the area of the same base station system

A) commanding the base station controller of said base station system to switch a connection directly between the base stations of said mobile stations under control of the mobile services switching centre MSC,

B) forwarding the uplink transmission frames transmitted by a base station as such to another base station.

C) commanding the base stations to disregard whether the transmission frame is of uplink or downlink type.

7. A call control method in a mobile communication system comprising at least mobile stations (MS); base station systems, each comprising a base station controller (BSC) and several base stations (BTS); mobile services switching centres (MSC), each comprising call control means and switch means for controlling and switching calls of mobile stations; and transcoder units (TRCU), each comprising encoding and decoding means for decoding an encoded speech signal

received from a mobile station, and for encoding a speech signal to be transmitted to a mobile station; network connections that are allocated call-specifically between a base station, a base station controller and a mobile services switching centre, a speech signal being transmitted in transmission frames over said network connections, the base stations and the transcoder units comprising means for building, debuilding and synchronizing the transmission frames, the uplink transmission frames transmitted by the base station to the transcoder unit containing synchronizing information on the basis of which the transcoder unit times the transmission of the downlink transmission frames to the base station, c h a r a c t e r i z e d by

checking, prior to allocating network connections for a call, whether the calling and the called mobile station are located in the area of two base station systems having a direct network link between them,

if the mobile stations are located in the area of two base station systems having no direct network connection between them, switching a call via a mobile services switching centre,

if the mobile stations are located in the area of two base station systems having a direct network link between them,

A) commanding said base station controllers of the base station systems to switch a connection directly between each other, and further between the base stations of said mobile stations under control of the mobile services switching centre (MSC),

B) forwarding the uplink transmission frames transmitted by a base station as such to another base station.

C) commanding the base stations to disregard whether the transmission frame is of uplink or downlink type.

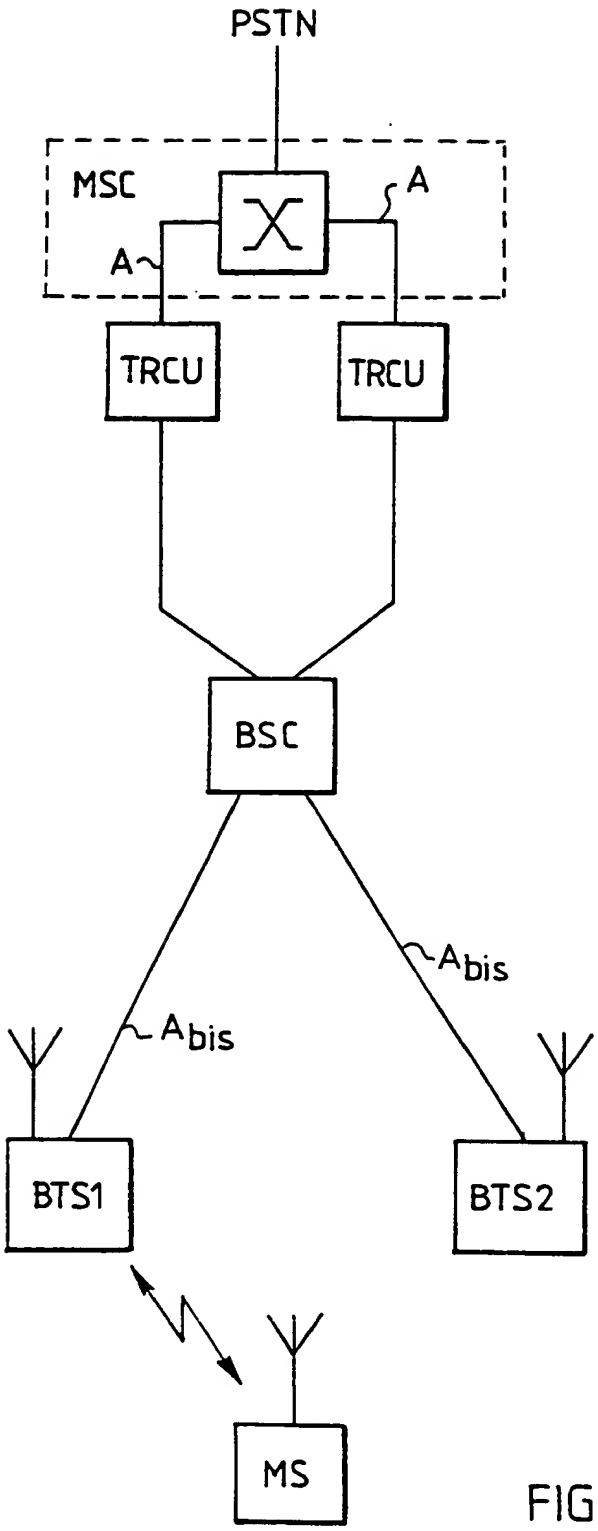

FIG. 1

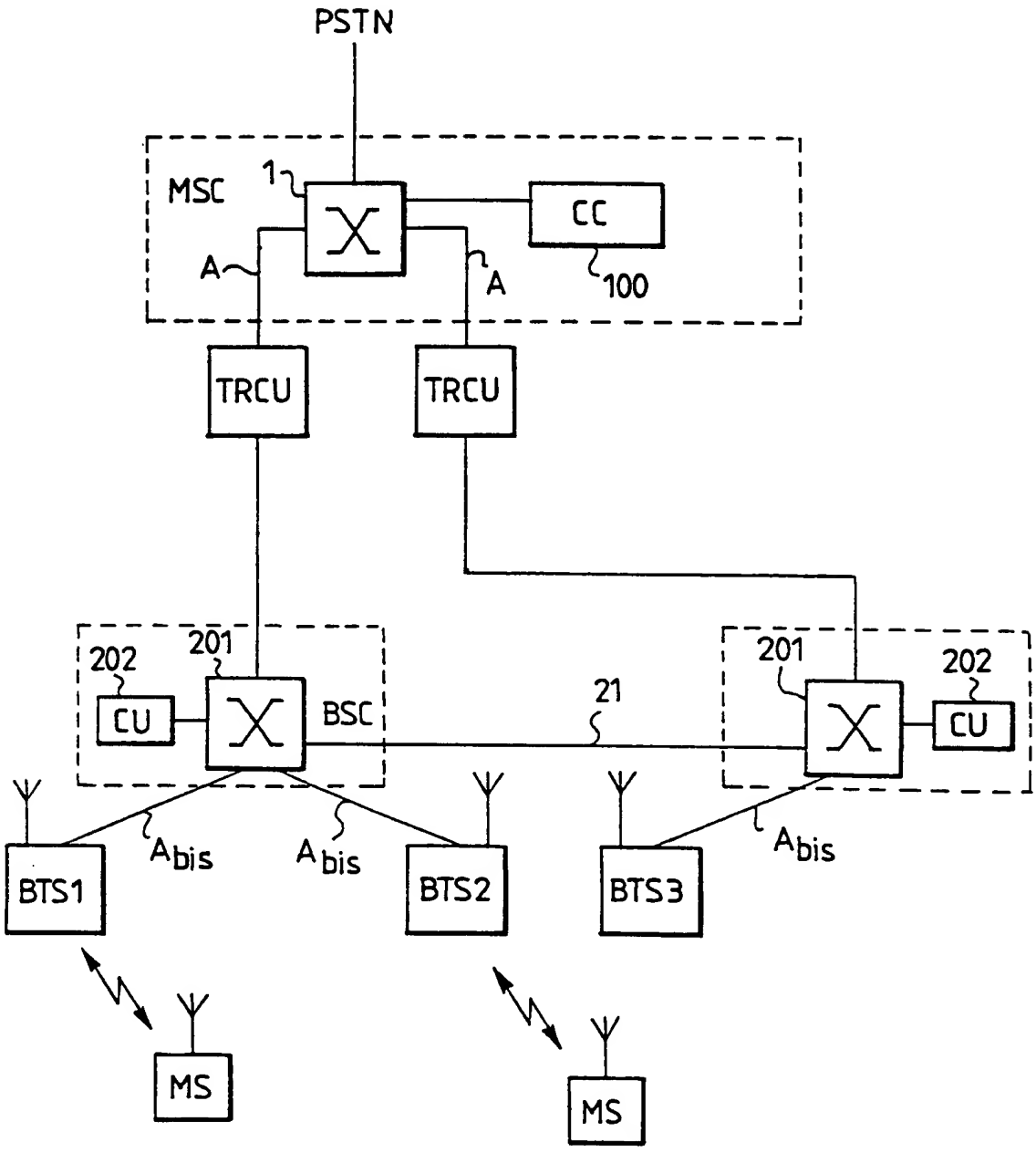

FIG. 2